Design of Social Infrastructure and Services Taking into Account Internal Migration by Age Cohort

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Abstract

Background: European cities and regions are facing depopulation and an ageing population, leading to a shift in the demand and supply of goods and giving rise to the silver economy. This demographic change has an impact on urban and regional planning, which is influenced by both internal and external migration. **Objectives:** Based on the hypothesis that the attractiveness of locations also depends on the age of the inhabitants, the paper investigates the gravitational effects on the intensity of migration flows by age cohorts. **Methods/Approach:** This study examines how factors that influence the retention or attraction of people towards specific areas affect migration between age groups at different hierarchical spatial levels, using the gravity model implemented at the Slovenian spatial levels NUTS 2 and NUTS 3. **Results:** Distance is least important for the 65-74 age group, while wages influence only the youngest cohorts. The capacity of care homes has a significant influence on the attractiveness of older cohorts to move between NUTS 2 regions. There is a high correlation between the factors at the municipal and NUTS 3 levels for the population aged 75+. The factors at NUTS 2 and NUTS 3 levels show a strong correlation for those under 65. **Conclusions:** These results can form a basis for the development of the silver economy as they show the need for adapted infrastructures and services for older adults. As the age structure is changing, authorities should adapt infrastructures and services to the different levels of central places/regions. The growing number of older people makes research into optimal solutions for long-term care a crucial factor for the silver economy.

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Introduction

The shrinking of cities and regions is a growing phenomenon in all European cities and regions and, at the same time, a popular topic in international regional and urban research, the first publications of which were discussed in detail by Oswalt and Bundes (2005). In the post-industrial society, the number of industries and employees has declined in most industrialised cities in developed countries. Some cities, such as Detroit, even went bankrupt due to the migration of industry. While the decline of the first cities was related to the loss of production factors, especially raw materials (Manaos), which was followed by suburbanisation with the availability of private vehicles and quick access to city centres (Li et al., 2024), today the fundamental problem is the ageing of the population and demographic decline in general. In some countries, however, the contradiction between the decline in urban population and the increase in building land is also becoming a pressing problem for many smaller cities (Li et al., 2022).

Simulation and optimisation models for building land acquisition are an important part of decision-making models to support land policy and a fundamental way to ensure that even smaller cities can make sustainable use of land resources (Li et al., 2024). With the development of spatial planning technology, optimisations in decision-making on the location and timing of investments and, above all, simulations, the theoretical foundations and methodological approaches for the optimal allocation of building land - housing and social infrastructure - are constantly being updated. However, these processes do not take sufficient account of the optimal spatial development in relation to the different age structures of the population, which require different living environments and, above all, different social infrastructures in the neighbourhoods where they live. Many optimisation models based on multi-criteria linear programming (Das et al., 2015), system dynamics and Markov chain processes (Fang et al., 2019; Wang et al., 2022a Wang et al., 2022b; Liang et al., 2018) solve the question of what the dynamics of property construction should be but do not take into account the importance of the attractiveness of the location in relation to the age structure of the population.

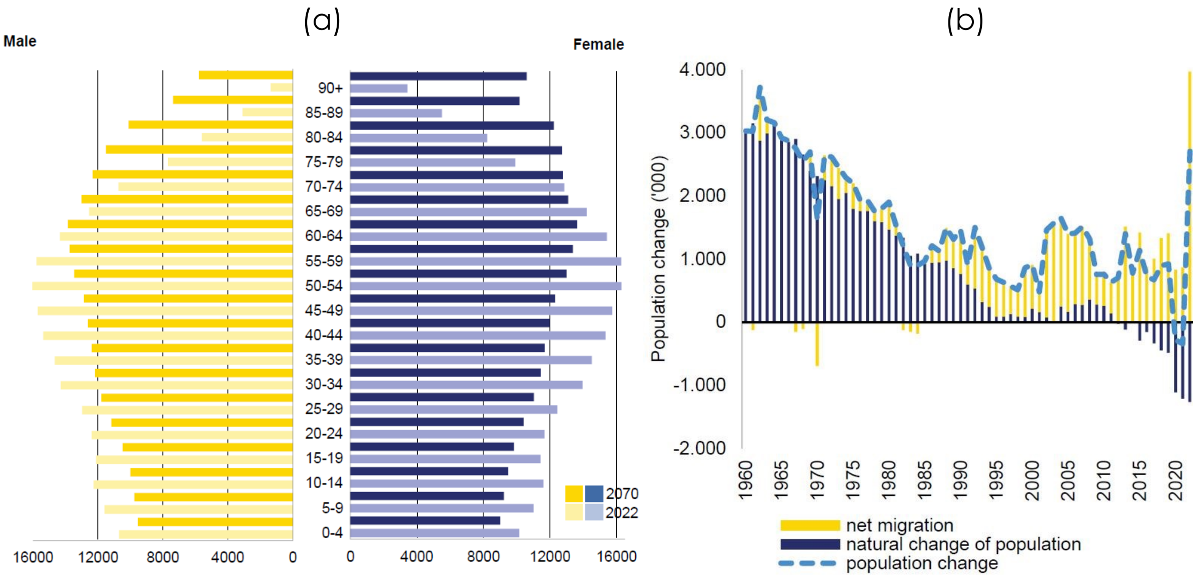
As Li et al. (2024) note, optimisation models of spatial and temporal allocation do not focus on the selection of indicator factors. Therefore, in our study, we focused on the issue of location attractiveness, i.e. factors that attract population from elsewhere to the chosen spatial unit or ensure that residents do not move away. Knowing the value of these indicators will make it much easier to successfully plan land utilisation and meet the demand for housing and social infrastructure in their vicinity.

The question arises as to whether investments in space and other factors have characteristically different effects on the intensity of growth or shrinkage of an area and thus influence migration flows with regard to the age of the inhabitants. We hypothesise that the attractiveness of locations also depends on the age of the inhabitants. We have investigated the gravitational effects on the intensity of migration flows by age cohorts and the spatial organisation of territorial units.

Population ageing and shrinking areas

European cities and regions are ageing and shrinking (European Commission - EC, 2023). The EC has summarised the EUROPOP2023 population projections published by Eurostat in March 2023. Based on these demographic fundamentals for the age-related expenditure projections for the 27 EU Member States and Norway, the EC forecasts fertility, mortality and net migration for the years 2022–2100. Figure 1a shows that the number and percentage of 65+ (men) and 75+ (women) cohorts will increase significantly by 2070, and the population decline in the EU is shown in Figure 1b.

Figure 1
European Union: (a) Population by age group and sex, 2022 and 2070 (thousands), (b) Population change, 1960–2020.



Source: European Commission (2023), based on Eurostat data.

The population decline affects population density, which varies by state and region and between urban and rural areas. Migration also influences this decline or growth. Immigration from non-European countries mitigates the sharp population decline in the EU member states. The impact on the EU as a whole is shown in Figure 1b, but there are significant differences between individual countries. In the period 1960-2020, Spain, France, Germany and Italy recorded the largest net inflows, while Poland, Bulgaria, Romania, Portugal, Lithuania and Croatia recorded the largest outflows. However, the differences between rural and urban areas within the individual countries are large. The main reasons for immigration or emigration can be analysed using the gravity approach. The theoretical principle of the gravity model is twofold:

- the degree of interaction is directly proportional to the size of the masses (number of inhabitants, economic power of the areas) and
- the degree of interaction decreases with the distance that separates them.

The first papers on the topics of "gravity model" and "migration" appeared in the Web of Science (WoS) Core Collection in 1966 and the second in 1970 (Christian & Braden, 1966; Johnston, 1970).

The dynamics of population density in countries and regions have a significant impact on the economy. As shrinking and ageing areas have fewer human resources and consume less productive output specific to younger populations, they require more products and services typical of older inhabitants. Therefore, the structure of age cohorts should influence changes in spatial planning and product supply. Eurostat confirms the thesis of Angel et al. (2010, 2011) that shrinkage dynamics are lower in larger cities than in small towns and rural areas. With the industrial transition to Industry 4.0 and Industry 5.0, declining fertility and ageing are significantly changing the demographic structure (Bogataj et al., 2019a, 2019b, 2020a, 2020b; Calzavara et al., 2020). The relative shrinkage of LAU2 spatial units in the EU and the European Economic Area (EEA) in the first decade of this millennium is presented in Drobne and Bogataj (2022). From this paper, we can see that in almost 41 per cent of EU and other EEA countries, even more than 40 per cent of urban LAUs 1 are shrinking demographically. We can also see that the proportion of depopulated LAUs 1 is higher in the east than in the western EU member states.

However, all these articles lack insight into migration by age structure and an answer to the question of how strongly individual factors, from investment in built space to the organisation of social infrastructure, influence individual age cohorts and how changes in age structure dictate the approach to spatial plans. From an organisational perspective, it is also important to answer the question of how hierarchical spatial structures influence migration. Therefore, migrations along different levels of spatial hierarchies are observed here.

We use NUTS and LAU abbreviations in this article. NUTS (Nomenclature of Territorial Units for Statistics) regions and LAU (Local Administrative Units) are classification systems used by the EU for statistical and administrative purposes. NUTS is a hierarchical system that divides countries into different levels of administrative regions for statistical reporting. NUTS regions are categorised into three levels: NUTS 1 (larger regions), NUTS 2 (smaller regions), and NUTS 3 (sub-regions or counties). LAU represents the lowest level of administrative divisions within the NUTS framework. LAU is divided into two levels: LAU 1 and LAU 2. LAU 1 corresponds to municipalities or equivalent local administrative units with a higher level of administrative authority. LAU 2 refers to smaller administrative units, such as districts or neighbourhoods, within the larger municipalities.

Literature review

In the journals indexed by the Web of Science (WoS), the keyword "shrinking city" is relatively new and was first mentioned in 2005 (Groth & Corijn, 2005). In the first decade of this millennium, there were only six articles with this keyword. The first to address the issue of migration in shrinking cities was Hillmann (2009), but he, too, only observed movements within the city. In this first decade, only Hanhörster (2009) pursued the idea of analysing (internal) migration flows in shrinking cities.

Although the gravity model in migration research is discussed in 454 articles in journals indexed by WoS, this topic relates more to shrinking or growing cities or regions. Only six articles address shrinking and growing cities or regions in the context of population ageing, all published in the last five years (Drobne et al., 2019; Arends-Kuenning et al., 2019; Bogataj et al., 2019b; Lin, 2020; Drobne & Bogataj, 2022; Zuo et al., 2023).

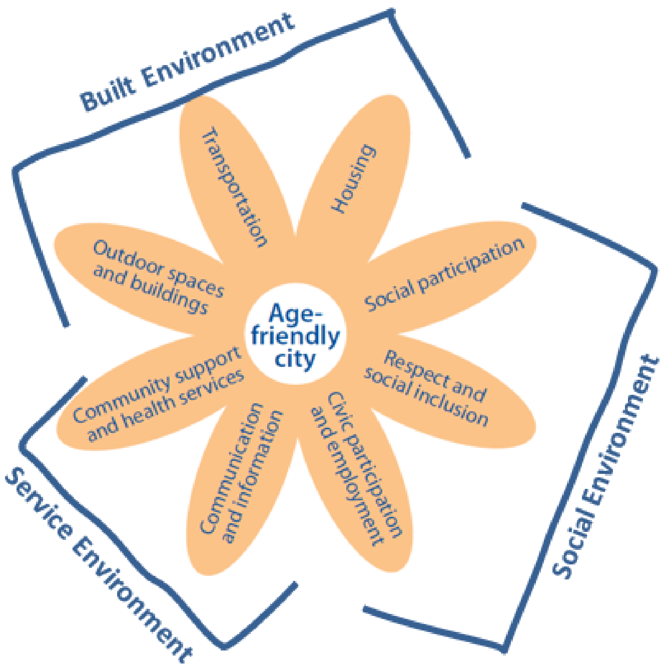
In the second decade, 159 articles were published. So far, there are 215 articles from the WoS Core Collection. The authors focus more on the renewal of industrial areas (Rienow et al., 2014). As highlighted in these articles by Wolff et al. (2018), the trend towards lower population density is more notable for small and medium-sized urban LAUs. Wolff et al. (2018) have also shown that the population has been shrinking faster in the last two decades of this millennium. The cases of high negative structural dynamics can be seen in the post-socialist states of Eastern Europe due to falling birth rates and emigration, but also in the post-industrial areas of Western Europe due to falling birth rates and changes in industrial activities. Ageing is expected to continue in the third and fourth decades in the East and West (European Commission, 2023); government and industry should therefore prepare for this phenomenon.

The articles on the challenges posed by the ageing of the European population and the related issues of migration of older citizens date mainly from the last decade when we started to become aware of the fact that as the population ages, the environment and services that the population prefers are also changing due to ageing. De Jong et al. (2020) have highlighted the role of welfare in location choice, which influences intra-European migration decisions across the European life course.

Some American authors also emphasised the importance of looking for optimal solutions for a longer time horizon. Especially when planning according to the wishes and needs of the ageing population, it should not be neglected that the wishes of the younger cohorts regarding the spatial standard in old age differ from the wishes of the older age groups.

Black and Hyer (2020) examined differences in the requirements of older cohorts, including baby boomers and older generations, for age-friendly communities where most residents are 50+ years old. The results of the investigation show significant differences between all cohorts in all WHO domains (see Fig. 2), with significant differences in preferences for housing, outdoor spaces, employment and participation in social activities (World Health Organisation, 2007). A certain difference between baby boomers and older generations was also found in Slovenia (Bogataj et al., 2020c), which shows that spatial comfort and adaptation of housing to older adults is more important for baby boomers than for older generations. This should influence the dynamics of building specialised housing units.

Figure 2
Eight domains essential for age-friendly communities are grouped into three clusters.



Source: World Health Organization (2007) and authors' elaboration.

Researchers report on the impact of parameters such as housing rents and prices, home ownership, national housing policy, demographic figures and economic conditions on mobility. In the first decade of this millennium, we find work by Engelhardt (2003) looking at equity constraints, Smith and Smith (2007) and Cunningham and Engelhardt (2008) looking at the effects of housing capital-gains taxation on migration, and many others looking at macro-level migrations, Ferreira et al. (2010) looking at the effects of housing bankruptcies on migration intensity, Conway and Houtenville (2003) focusing on older adults.

If we select the topics "older adults" and "migration", we find 638 articles in the Web of Science Core Collection (WoS) that examine the migration behaviour of older adults. Suppose we select the topics "gravity model", "older adults", and "migration"; only one article in WoS deals with the migration of the oldest citizens (Gu et al., 2022). In this article, a push-pull analysis is proposed. The results of a Poisson pseudo-maximum likelihood gravity model in this article have shown that the quantity and quality of health services have push and pull effects on older adults' decision to migrate, in addition to two factors, namely the influence of family needs and the cost effect that affects regional economic development. Karpestam (2018), not listed in WoS, also examined the gravity model in migration studies of different age cohorts in connection with new buildings. He found that new housing has recently become less accessible for certain age cohorts, even in Sweden. He investigated how the characteristics of new housing affect inter-community mobility for different age cohorts by using a gravity model that models migration as a function of origin and destination. His results show that new construction in the new millennium has affected migration within commuting regions more than between commuting regions. He also found significant negative effects on net migration into new builds from the other areas. The impact was stronger for young adults than for older adults.

The first report on migration in Slovenia, which also included older adults (focussing on their tourist activities and second residence), was presented by Bogataj and Drobne (2011). These were the results of the ESPON ATTREG project (Espon, 2013), which aimed to investigate the motivation and behaviour of migration flows and daily commuting of students, tourists, older people migrating to their second home, students and other "part-time" commuters – but especially the behaviour of human resources in gross migrations and daily commuting – between regions. At that time, one of the key elements of the European Commission's cohesion policy in 2010 was the contribution of new transport infrastructure development to regional economic development, so the paper focussed on distances in the gravity model. Bogataj and Drobne (ibid.) used the gravity approach to analyse gross migration in Slovenia (annual average 2000-2006) also as a function of GDP. The regression model of gross migration GM between the regions at the NUTS 3 level in Slovenia yielded the following equation:

$$GM_{ij} = 3.89 \cdot 10^{-5} \cdot P_i^{0.84} \cdot P_j^{0.83} \cdot d_{ij}^{-1.34} \cdot K_{GDP,i}^{0.90} \cdot K_{GDP,j}^{1.71},\ R^2 = 0.85 \qquad (1)$$

where P_i and P_j are the population size in the origin and destination regions respectively, d_{ij} is the distance between the origin and destination regional centres, and $K_{GDP,i}$ and $K_{GDP,j}$ are the ratio between the GDP per capita in the NUTS 3 region and the GDP per capita at national level.

In the studies by Bogataj and Drobne, the list of factors was later expanded, but the examination of the individual age cohorts according to the hierarchical levels was not the subject of consideration. In our presentation here, we have therefore examined the effects of various factors on the migration of citizens from Slovenian municipalities to other regions at the NUTS 2 and NUTS 3 levels, considering various age cohorts, which structure will change in the next years rapidly.

Note that at the NUTS 1 level, Slovenia is the whole country, at the NUTS 2 level, Slovenia is divided into two cohesion regions, and at the NUTS 3 level, Slovenia is divided into 12 statistical regions. At a hierarchical level below NUTS 3, Slovenia is divided into 212 municipalities (LAUs).

Methodology

Based on the hypothesis that the attractiveness of locations also depends on the age of the inhabitants, the gravitational effects on the intensity of migration flows are examined according to spatial organisation and age cohorts. We analysed the influence of some factors on migrants according to different age cohorts and at different spatial levels in the normalised spatial interaction model as proposed by Drobne and Bogataj (2022) and modified here:

$$M_{ij}^{(c,s)} = k\, K(d_{ij})^{\beta} \prod_r K(r)_i^{\gamma(r)}\, K(r)_j^{\alpha(r)}, \quad (2)$$

where $M_{ij}^{(c,s)}$ is the estimated intensity of migration flows of age cohort c at a spatial level from a municipality of origin i to a municipality of destination j; age cohorts were defined as c = 0–65, 66–74, 75+; analyses were conducted for three spatial levels, s = municipal level, NUTS 3 level, NUTS2 level; k is the constant of proportionality; $K(d_{ij})$ is the coefficient of the shortest distance by state road network between the centre of origin municipality i and the centre of destination municipality j; $K(r)_i$ and $K(r)_j$ are coefficients of factors r in origin i or destination j, defined as the value of factor in municipality i and municipality j, respectively, divided by the average value of this factor in Slovenia (see Table 1).

At the municipal level, we have analysed the migration flows between municipalities in the same (statistical) NUTS 3 region; at the NUTS 3 level, we have analysed the inter-municipal migration flows between NUTS 3 regions but in the same NUTS 2 region; and at the NUTS 2 level, we have analysed the migration flows between municipalities of different NUTS 2 regions.

We analysed the internal migration flows between municipalities in Slovenia as an average for 2020/2021. Model (1) was linearized and solved with IBM SPSS using ordinary least squares (OLS) regression analysis for three age cohorts and three spatial levels and the significant values of α, β and γ were compared.

To better illustrate the relationships between the factors influencing different cohorts for different hierarchical relationships between origin and destination of migration flows, we summarised the power of a factor in immigration and emigration and calculated the ranks of the sums. The preferences of the different age groups were then analysed using a correlation analysis. As the ranks are integers, we used the formula (3) to calculate the Spearman correlation coefficient, which measures the degree of similarity between two ranks:

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (3)$$

Table 1
Factors in spatial interaction model (2) as choosen by authors.

Notation	Factor value	Additional description	Source
$M'^{(c,s)}_{ij}$	Number of migrants in age cohort c for year y from municipality of origin i to municipality of destination j	Average of yearly values for 2020/2021	SORS and authors' calculation
$M^{(y,s)}_{ij}$	Estimation of the number of migrants in age cohort c for year y from municipality of origin i to municipality of destination j	The estimation of the real value regarding model (1)	Authors' calculation
$K(d_{ij})$	Coefficient of the fastest time-spending distance between municipal centre of origin i and municipal centre of destination j	The ratio between the factor value for a pair of municipal centres and the average factor value for Slovenia for 2021	SIR and authors' calculation
$K(POP_{\circ})$	Coefficient of the number of inhabitants in the municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2021	SORS and authors' calculation
$K(UEMP_{\circ})$	Coefficient of registered unemployment rate in the municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2021	SORS and authors' calculation
$K(GEAR_{\circ})$	Coefficient of gross earning per capita in the municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2021	SORS and authors' calculation
$K(NDWE_{\circ})$	Coefficient of number of dwellings per 1000 inhabitants in the municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2021	SORS and authors' calculation
$K(PDM2_{\circ})$	Coefficient of average price per m^2 of dwelling in the municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2020/2021	SMARS and authors' calculation
$K(MREV_{\circ})$	Coefficient of municipal revenue per capita	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2021	MFRS and authors' calculation
$K(AGEI_{\circ})$	Coefficient of ageing index in municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia for 2021	SORS and authors' calculation
$K(HELD_{\circ})$	Coefficient of capacity of care homes in the municipality	The ratio between the factor value for the municipality and the average factor value for Slovenia at end of 2021	CSSI and authors' calculation
$K(SR_{\circ})$	Coefficient of number of single rooms in care homes	The ratio between the factor value for the municipality and the average factor value for Slovenia at end of 2021	CSSI and authors' calculation
$K(TAP_{\circ})$	Coefficient of number of temporary accommodation places	The ratio between the factor value for the municipality and the average factor value for Slovenia at end of 2021	CSSI and authors' calculation
$K(DCP_{\circ})$	Coefficient of number of day-care places	The ratio between the factor value for the municipality and the average factor value for Slovenia at end of 2021	CSSI and authors' calculation
$K(SDWE_{\circ})$	Coefficient of number of dwellings serviced by the care provider	The ratio between the factor value for the municipality and the average factor value for Slovenia at end of 2021	CSSI and authors' calculation
$K(COVCH_{\circ})$	Coefficient of the index of coverage of the care needs of elderly people in care homes	The ratio between the factor value for the municipality and the average factor value for Slovenia at end of 2021	CSSI and authors' calculation

Notes: SORS - Statistical Office of the Republic of Slovenia (SORS, 2023), SIR - Slovenian Infrastructure Agency (SIR, 2023), SMARS - Surveying and Mapping Authority of the Republic of Slovenia (SMARS, 2023), MFRS - Ministry of Finance of the Republic of Slovenia (MFRS, 2023), CSSI - Community of Slovenian Social Institutions (CSSI, 2023).
Source: authors' elaboration.

Results

Table 2 shows the regression coefficients of the linearized model (2). Presentation is given according to three different hierarchical spatial levels (LAU 1 municipal level, NUTS 3 region level and NUTS 2 region level) and according to three age cohorts of 0–65, 66–74 and 75+ years; the values of the regression coefficients for which the p-value is greater than 0.05 are given in brackets.

Table 2

Statistics of standardised coefficients α, β and γ for cohorts 0–65, 66–74, and 75+ year-olds at municipal, NUTS 3 and NUTS 2 hierarchical spatial levels (internal migration in Slovenia in 2020/2021; ANOVA p-value <0.001 for all).

Spatial level	LAU 1 level			NUTS 3 level			NUTS 2 level		
Age cohort	**0–65**	**66–74**	**75+**	**0–65**	**66–74**	**75+**	**0–65**	**66–74**	**75+**
R	0.881	0.734	0.727	0.751	0.645	0.618	0.779	0.660	0.618
R^2	0.776	0.539	0.528	0.563	0.416	0.382	0.607	0.436	0.382
Adjusted R^2	0.775	0.528	0.518	0.561	0.402	0.361	0.605	0.422	0.362
SE	0.691	0.603	0.693	0.749	0.562	0.556	0.707	0.545	0.555
No. of obs.	3,697	1,154	1,255	6,424	1,153	833	6,171	1,094	826
ANOVA stat. F	471.249	48.782	50.904	305.553	29.667	18.393.	351.654	30.545	18.300
β	-.575	-.371	-.452	-.378	-.206	-.374	-.338	-.310	-.402
$\gamma(POP)$	.473	.595	.571	.446	.464	.398	.583	.536	.586
$\alpha(POP)$	.422	.301	.194	.434	.258	.264	.563	.343	(.167)
$\gamma(UEMP)$	-.025	(.034)	(-.048)	(-.007)	(.038)	(-.032)	(.003)	(-.011)	(.074)
$\alpha(UEMP)$	(-.015)	(-.017)	(-.053)	(.006)	(.001)	(-.016)	.024	(.017)	(.040)
$\gamma(GEAR)$	.018	(.038)	.048	.043	.106	.078	.054	.122	(.060)
$\alpha(GEAR)$	.017	(.006)	(.003)	.027	(.021)	(.024)	.071	(.027)	(.033)
$\gamma(NDEW)$	.097	.170	.092	.105	.146	.124	.144	.108	(.096)
$\alpha(NDEW)$	.154	.176	.103	.152	.227	.130	.189	.214	(.030)
$\gamma(PDM2)$	-.038	(-.034)	-.064	.031	.076	(.026)	.024	(.007)	-.133
$\alpha(PDM2)$	(-.014)	(.029)	-.078	.065	.097	(.053)	.027	(-.006)	-.109
$\gamma(MREV)$	.068	.052	.072	(.002)	(-.038)	(.010)	(-.003)	(-.034)	(-.011)
$\alpha(MREV)$	.023	(.039)	(.005)	(-.001)	(-.016)	.063	(-.012)	(-.004)	(.031)
$\gamma(AGEI)$	(-.002)	(.026)	.059	(.014)	(.057)	.087	(.013)	.104	(.020)
$\alpha(AGEI)$	(-.016)	(-.009)	(-.015)	.032	(.024)	(.075)	(.020)	(-.009)	(.045)
$\gamma(HELD)$	(.015)	(-.069)	(-.064)	(-.027)	(-.069)	(-.070)	-.079	(.011)	(.131)
$\alpha(HELD)$	(.042)	.178	.588	(-.052)	(-.049)	.165	-.051	(.077)	.291
$\gamma(SR)$	(-.019)	(.036)	(.024)	(.042)	(.099)	(.035)	.063	(-.003)	(-.118)
$\alpha(SR)$	(-.032)	(.002)	-.156	.075	(.124)	(-.031)	.061	(-.036)	(-.078)
$\gamma(TAP)$	.055	(.007)	(.020)	.020	-.123	(-.060)	-.032	-.078	(-.009)
$\alpha(TAP)$	.035	(.010)	(.013)	.023	-.113	-.106	-.032	(-.023)	(-.031)
$\gamma(DCP)$	(.021)	(.001)	(.002)	(.014)	(-.044)	(.014)	(.015)	(-.052)	(-.098)
$\alpha(DCP)$	(.025)	(.032)	(-.034)	(.000)	(-.050)	(-.082)	(-.020)	(-.063)	(-.064)
$\gamma(SDWE)$	.021	.060	(.035)	.099	.058	.104	.070	(.065)	(.060)
$\alpha(SDWE)$	(.013)	(-.007)	(.022)	.090	.070	(.033)	.071	(.039)	(.035)
$\gamma(COVCH)$	.038	-.066	-.081	-.062	-.130	(-.073)	-.069	-.104	-.115
$\alpha(COVCH)$	.050	(-.003)	(-.022)	-.072	(-.043)	(-.024)	-.082	(-.016)	(-.030)

Note: The values of the regression coefficient where p-value > 0.05 are in parentheses.
Source: Authors' work

The adjusted R2 of the regression models are relatively high for inter-municipal flows (51.8% to 77.5%) and slightly lower for migration at the NUTS 3 (56.1% to 36.1%) and NUTS 2 (60.5% to 36.1%) levels. At each spatial level, they are highest for the youngest cohort and lowest for the oldest cohort - which correlates strongly with the number of observations in particular. Overall, the distance of migration, the population and the number of dwellings have a statistically significant influence on migration for all cohorts considered and at all three spatial levels. The statistical significance of the other factors varies depending on the cohort and spatial level.

To better understand the relationships between the factors affecting different cohorts in the context of migration flows, we have summarised the influence of each factor on immigration and emigration. The ranks of the sum of the powers are shown in Table 3 and the impacts of the different factors are plotted in Figure 3 for the municipal (LAU 1) and regional (NUTS 3 and NUTS 2) levels.

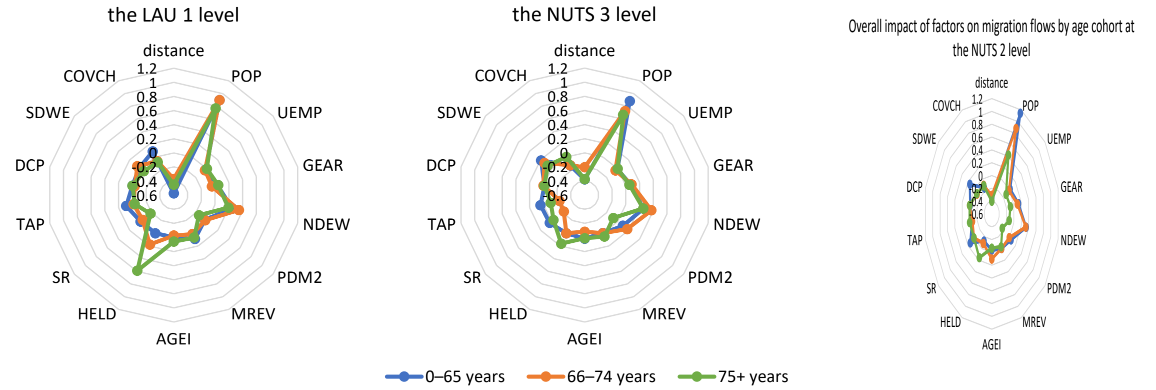
Table 3
A rank of the sum of the power of factors (immigration and emigration) for internal migration in Slovenia in 2020/2021 for different hierarchical spatial levels and different cohorts.

Spatial level	LAU 1 level			NUTS 3 level			NUTS 2 level		
Age cohort	0–65	66–74	75+	0–65	66–74	75+	0–65	66–74	75+
Distance	1	1	1	1	3	1	1	1	1
Population	14	14	14	14	14	14	14	14	14
Unemployment	3	5	8	4	6	6	8	6	5
Gross earning	9	3	9	10	10	10	11	11	7
Number of dwellings per capita	13	13	12	13	13	13	13	13	3
Dwelling price	2	7	3	11	12	3	9	7	2
Municipal revenue per capita	12	10	11	5	7	9	7	8	9
Ageing index	4	8	10	7	5	8	5	12	8
Care homes capacity	4	12	13	6	7	12	3	4	13
Single rooms in care homes	4	4	2	8	2	4	10	8	10
Temporary accommodation places	11	9	6	9	1	2	4	5	10
Day-care places	4	6	7	3	7	5	6	8	10
Dwellings serviced by the care provider	8	11	5	12	11	11	12	2	6
Coverage of the care needs of elderly people in care homes	10	2	4	2	4	6	2	3	4

Source: Authors' work

An examination of the bottom and top 10% of the ranks - overall the 1/5th strongest influencers of migration - confirms many of the findings from the literature that migration distance and population have the strongest influence on the decision to migrate. This is true for all three cohorts at all three spatial levels - with one exception for migrants between NUTS 3 regions in the middle age cohort (66-74 years), where the factor number of temporary accommodation places in the municipality plays a more important role than distance. With the exception of the oldest cohort, the number of dwellings in the municipality also has a significant influence on the decision to move (applies to all spatial levels considered).

Figure 3
The overall impact of factors on migration flows by age cohort at the level of municipalities (LAU 1), NUTS 3, and NUTS 2 regions.



Notes: POP - population, UEMP - unemployment, GEAR - gross earning, NDEW - number of dwellings per capita, PDM2 - dwelling price, MREV - municipal revenue per capita, AGEI - ageing index, HELD - care homes capacity, SR - single rooms in care homes, TAP - temporary accommodation places, DCP - day-care places, SDWE - dwellings serviced by the care provider, COVCH - coverage of the care needs of elderly people in care homes.
Source: Authors' work

Overall, the social infrastructures and services considered in the study also have a significant impact, particularly on the two oldest cohorts (66–75 and 75+). At the level of moves between municipalities within the same NUTS 3 region, the capacity of care homes, the number of single rooms in care homes and the general index of coverage of the care needs of older people in care homes are important factors; at the level of moves between NUTS 3 regions, the number of single rooms in care homes and the number of temporary accommodation places are important factors. At the level of moves between NUTS 2 regions, the number of flats serviced by the care provider is important in addition to the capacity of care homes. The general index of coverage of care needs of older people in care homes also has a significant impact on the decision to move over longer distances (inter-regional moves) for the youngest cohort considered (0–65 years).

Table 4
The rank correlation of the intensity of factors influencing migration between cohorts at the same spatial level.

0–65 and 66–74			66–74 and 75+			0–65 and 75+		
LAU 1	NUTS 3	NUTS 2	LAU 1	NUTS 3	NUTS 2	LAU 1	NUTS 3	NUTS 2
0.53	0.69	0.62	0.73	0.70	0.32	0.53	0.55	0.13

Source: Authors' work

Table 5
The rank correlation of the intensity of factors influencing migration of the same cohorts between two spatially designed levels.

LAU 1 level			NUTS 3 level			NUTS 2 level		
0–65	66–74	75+	0–65	66–74	75+	0–65	66–74	75+
0.49	0.57	0.83	0.83	0.50	0.39	0.44	0.40	0.56

Source: Authors' work

A comparison of preferences between the age cohorts was carried out using a correlation analysis. For this purpose, we calculated the Spearman correlation coefficient, which measures the degree of similarity between two rankings (two columns in Table 3). The results are available in Tables 4 and 5. We can see a significant correlation in the ranking of factors between the population aged 66-74 and 75+ at municipal and NUTS3 levels. There is also a significantly similar ranking between the municipal and NUTS 3 levels for the 75+ cohort and between the NUTS 3 and NUTS 2 levels for the 0-65-year-old cohort.

Conclusions

The gravity model for goods, finance or population in economic geography is based on Newton's findings. Newton's law states that two bodies always attract each other with a force proportional to the mass at the point of origin and the destination and that the force of attraction decreases proportionally to the square of the distance between these objects. In international economics, this law was introduced by Walter Isard (1954), who analysed bilateral trade flows as a function of economic size and distance between two spatial units – countries. Initial results have already shown that trade tends to decrease with increasing distance. Today, these aspects are also integrated into the global supply chain (Bogataj et al., 2024). The study of migration flows also came to similar results. The first study of this kind was published in 1966 by Cristian and Braden in the Web of Science Core Collection (WoS). 455 articles dealing with migration using the gravity approach can be found as results in the WoS. Having established that populations in Europe and other developed countries are ageing rapidly, the results of our research provide empirical support to a growing number of publications refuting the classification of migrants as a monolithic group without considering their age, highlighting differences in the requirements of older cohorts, including baby boomers and older generations, for age-friendly communities where most residents are over 50 years of age (e.g. Karpestam 2018; Black & Hyer, 2020; De Jong et al., 2020). Study results show significant differences between all cohorts in all WHO domains (see Figure 3), with substantial differences in preferences for housing, open space, employment and participation in social activities (World Health Organisation, 2007). Our results show differences between cohorts.

The research question was whether investments in space and other factors have significantly different effects on the intensity of migration flows depending on the age of the inhabitants. The answer is positive. In this study, we investigated the influence of various factors on the migration pattern of three different age cohorts among Slovenian municipalities and regions at two regional spatial levels. Particularly, we have studied the impact of the fastest time-spending distance between municipal centres, the number of inhabitants in the municipality, the registered unemployment rate, the gross earning per capita in the municipality, the number of dwellings per 1000 inhabitants, the average price per m^2 of dwelling in the municipality, municipal revenue per capita, ageing index in the municipality, the capacity of the care homes, coefficient of the number of single rooms in the care homes, the number of temporary accommodation places, the number of day-care places, the number of dwellings serviced by the care provider, and the index of coverage of the care needs of older people in the care homes in the municipality. All factors have been measured in the origin and destination. The flows have been considered between municipalities, NUTS 2 regions and statistical regions. The importance of these factors has been ranked for all levels of spatial units. There has been a very low correlation of ranking factors between cohorts 0–65 years old and 75+ years old inhabitants for migrations on the NUTS 2 level; the correlation of rank r_s was only 0.13, which means that priorities which attract the migrants or retain them are very different between population 0–65 years old and population 75+ in case of NUTS 2 migrations. We can conclude that the same is true for cohorts 6674 and 75+ years old inhabitants (r_s is only 0.32). It proves that younger cohorts have priorities, unlike the very old cohorts, when they wish to migrate to other NUTS 2 levels. A low correlation of ranks was also found between cohorts 75+ for migrations on NUTS 2 and NUTS 3 levels. When they migrate to other NUTS 2 regions, they change the ranking of priorities. The details are given in Tables 4 and 5.

Our findings contribute to the understanding of migration dynamics. They can provide policymakers and spatial planners with information on how to meet the needs of different age groups better as their share in the population structure changes over the years. The research results are based on the existing hierarchy of spatial units. The results can be improved by using location data of the individual places of origin and destination (geocodes of the residential units and destinations of the residents). A first improvement would also be possible by considering into account the delimitation of functional regions, which is the subject of our further research.

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